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Research Note

NORTHERN ROCKY MOUNTAIN
FOREST AND RANGE EXPERIMENT STATION

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FOREST FIRE -- THUNDERSTORM,

KNOCKOUT COMBINATION FOR WATERSHEDS

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Seldom are harmful effects of a forest fire upon a watershed as promptly and dramatically demonstrated as they were near the Gates of the Rocky Mountains on the Helena National Forest in August 1950. Summer thunderstorms, falling on an area severely burned a year before, gutted stream channels, washed out roads and bridges, carried away top soil, destroyed recreational and aesthetic values, and caused other striking damages. Adjacent, unburned areas in the path of the storm remained unharmed.

Each year a few of the numerous forest fires in the Northern Rocky Mountain Region get large enough to denude a significant portion of a watershed. Each year, also, a number of thunderstorms strike here and there with sufficient intensity to provide a real test of watershed conditions. Fortunately, both do not often hit the same area in the lethal "1-2" knockout combination of fire - then rain. This report documents such a case and shows how forest fires may set the stage for disaster. It is indeed fortunate that this flood occurred in a remote, unsettled area.

FIRE (THE SET-UP PUNCH)

On the afternoon of August 5, 1949, a lightning fire started on the north ridge of Meriwether Canyon (fig. 1) and burned out the entire Mann Gulch watershed, much of the lower half of Willow Creek, and smaller portions of both Elkhorn Creek and Meriwether Canyon.

It was an extremely hot fire, crowning almost everywhere in the dense growth of 60-70 year-old ponderosa pine and Douglas-fir on the north slopes and spreading with almost explosive violence across the grassy south slopes with their scattered and uneven stands of bushy pine trees.

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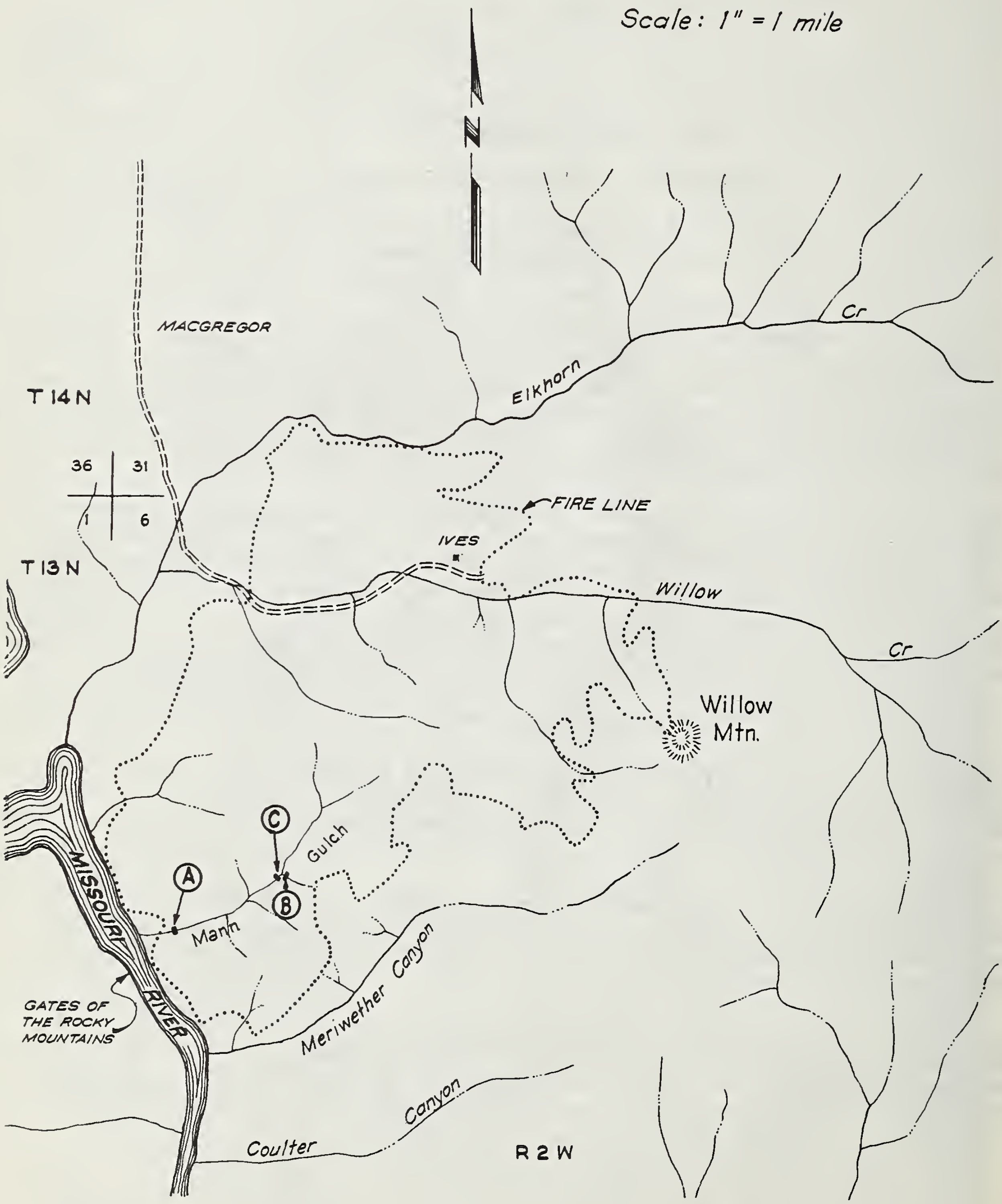
Fig. 1

A PORTION OF THE GATES OF THE ROCKY MOUNTAINS VICINITY SHOWING APPROXIMATE BOUNDARY OF THE 1949 FIRE AND LOCATION OF EROSION TRANSECTS A, B, & C.



Practically all of the trees within the boundaries of the fire were killed, with most of the needles and nearly all of the soil-protecting litter completely consumed, leaving on the ground only a layer of ashes and powdered limestone intermingled with an erosion pavement of coarser limestone fragments.

Several people who were on the ground soon after the fire were impressed by the unusual depth of fine, fluffy ashes, which some reported as ankle deep, on the ground under the fire-killed trees. A comparison of temperatures that have been recorded in burning forest litter and those used in processing native limestone into quicklime suggests that many of the finer limestone fragments intermingled with the forest litter may have been disintegrated by the intense heat into powdered limestone or quicklime. This would help to explain the unusual depth of the "ashes" and the striking amount of erosion that occurred later. The fine, powdered limestone would be very effective in quickly sealing the soil surface against infiltration and the particles not trapped in the soil pores would be readily carried away by the runoff water, thus adding to the specific gravity of the fluid and giving it great cutting and carrying power. This is only conjecture but is submitted here partly with the hope that someone will be moved to investigate its feasibility.

By July 1950 only a few weeds and shrubs had started growth under the burned timber, and the soil was still virtually unprotected against beating rain or running water. On the open, southerly slopes, all of the grass and nearly all of the shrubs burned to the ground. Investigations in 1950 showed that many of the formerly vigorous perennial grass clumps survived and made a rapid recovery but many of the weaker clumps, those with dead centers, and those on erosion pedestals were killed by the fire. Several of the brush species were sprouting from the root crowns.

Remeasurements made by personnel of the Northern Rocky Mountain Forest and Range Experiment Station in July 1950 of three erosion transects (A, B, and C in fig. 1) established in the fall of 1949 revealed that up to that time runoff and erosion from spring snow melt and other precipitation since the fire had been negligible, (figs. 7a, 7b, 9a, 9b).

THUNDERSTORM (THE KNOCKOUT BLOW)

Because of the remoteness of the area, it has been impossible to gather specific information concerning the storms which caused the destruction described herein. The following facts are fairly well established, however.

Two storms of high intensity occurred in the general vicinity, one on August 4 and one on August 11, 1950. Much, probably most, of the damage in Willow Creek was caused by the storm of August 4, that in Mann Gulch by the storm of August 11.

A witness who was at the Ives ranch during the August 4 storm stated that never before in 40 years of familiarity with the country had he seen "Willow Creek come down with such destructive force." The striking thing about this statement is that although Willow Creek drains roughly 13 square miles above the Ives ranch, practically all of the flood waters that went past the ranch arose on the approximately 2 square mile area that had burned a year earlier.

Another rancher near the mouth of Willow Creek measured approximately an inch of rain from the August 4 storm.

The recreation guard at Meriwether camp ground in the mouth of the canyon measured approximately one inch of water in an improvised rain can following the August 11 storm. Most of this fell during the first 45 minutes of the storm.

That the intense storms were not confined entirely to the burned area is proved by localized erosion observed on roads, and on areas of naturally barren or badly overgrazed range land outside of the burn. There was also some damage to small grain in lower Elkhorn Creek caused by the beating rain or accompanying hail.

In view of the known spotty nature of thunderstorms, it is realized that these fragmental records are mere indications of amount and intensity of the precipitation in the vicinity of Mann Gulch and the burned portions of Willow Creek.

DAMAGED WATERSHED (THE LOSER)

The appearance of Mann Gulch when it was examined on August 31 was sensational, to put it mildly. Practically the entire width of the valley floor at the mouth of the canyon, about 100 feet wide, was littered with rocks, trees and other debris deposited by the August 11 flood (figs. 2 and 3).

Signs of sheet and gully erosion were evident nearly everywhere. Yet a striking example of the effectiveness of litter in protecting the soil from erosion was found. On the steep, timbered, north-facing slope near the mouth of the gulch there was a place where the fire had killed a clump of young pine and fir trees but had not consumed the needles. Here, though the old litter had been destroyed by the ground fire, the dead needles which had fallen since the fire had been sufficient to reduce greatly the visible signs of runoff and sheet erosion. These needles had been washed and disarranged slightly but no shoestring gullies and only a few small silt deposits were evident. A hundred feet away where the fire had crowned, as it did most everywhere in Mann Gulch, and where there were no needles or other litter on the forest floor, the soil surface was cut by numerous shoestring gullies and worked into thousands of tiny terraces where washing soil had lodged behind rocks and twigs.

Erosion on the north-facing, burned-over forest land varied from relatively mild, as described above (fig. 4), to very severe, with numerous gullies nearly a foot wide and a foot deep (fig. 5). Wherever the runoff accumulated into side draws on the south side of Mann Gulch, the old alluvial fans were covered by fresh deposits of rocks and debris and in some cases new gullies were cut (fig. 6).

Erosion was less spectacular on the generally grassy south-facing slopes than on the timbered slopes, but runoff and sheet erosion occurred very widely here also. It seems probable that the current year's growth of herbage materially weakened the impact of the rainfall and that the firm soil, the fairly numerous plant crowns, and the gentler slopes, combined to reduce the amount of erosion that occurred. Many small gullies formed on the bare ground where clumps of brush were consumed by the fire.

Fig. 2 - Mouth of Mann Gulch in fall of 1949 shortly after fire. Drainage area 950 acres.

Fig. 3 - Mouth of Mann Gulch as it appeared on August 31, 1950, following the thunderstorm of August 11. Note heavy deposit of recent debris.

Fig. 4 - Type of erosion that occurred very commonly on the steep, formerly timbered slopes of Mann Gulch.

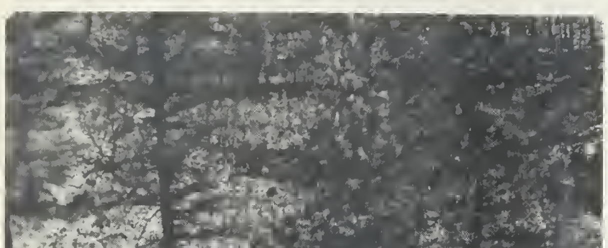


Fig. 5 - An example of very severe erosion on the formerly timbered slopes of Mann Gulch. Though less common than the type shown in fig. 4, there was much of this erosion class.

Fig. 6 - Rock deposits and a new gully on the alluvial fan of a draw coming into Mann Gulch from the south, about 3/4 mile from the river. Drainage area about 100 acres.

The erosion transects in Mann Gulch were remeasured and rephotographed on August 31. Transect "A" (fig. 7) crosses the main channel of Mann Gulch about one-fourth mile from the river. Transect "B" (fig. 8) is on a short, timbered side draw entering Mann Gulch from the southeast about a mile above the river. Transect "C" (fig. 9) is on the main channel just below transect "B".

The before and after views (figs. 7, 8 and 9) of the transect locations show what happened all along the main channel. At transect "A", for example, the original cross sectional area of 52 sq. ft. was enlarged by 17 sq. ft. of cutting and reduced by 1 sq. ft. of fill. Transect "B" had an original cross section of 21 sq. ft. and was enlarged by 15 sq. ft. or about 67 percent, and transect "C" with an original cross section of 49 sq. ft. was cut out by 12 sq. ft. and received 6 sq. ft. of fill.

Transect	Original section (sq.ft.)	Cutting (sq.ft.)	Fill (sq.ft.)	Final section (sq.ft.)
A	52	17	1	68
B	21	15	-	36
C	49	12	6	55

The damage to the main channel of Willow Creek was less spectacular than that in Mann Gulch, probably because Willow Creek is a considerably larger drainage, the main channel has a gentler gradient, and only about the lower half of the drainage was burned out. The most spectacular damages along the main channel were destruction of two small bridges, damage to a third, several hundred yards of a local road washed away in a narrow place where it followed the creek, numerous beaver dams filled with mud and debris or washed out, and general reworking of the stream channel throughout 2 miles, cutting here and filling there.

In one place about a mile below the Ives ranch, a mud and rock flow came out of a short, steep side drainage from the south depositing rocks and debris 2 to 3 feet deep along some 30 yards of the road (fig. 10).

About one-half mile above the Ives ranch, a drainage of about 500 acres and 2 miles in length heads just west of Willow Mountain and enters Willow Creek from the south. There had been a big flow from this canyon which deposited rocks and gravel over two acres of an alfalfa field between the canyon mouth and Willow Creek (fig. 11). Inspection of the main channel a short way above its juncture with this side drainage showed that practically no runoff occurred from the upper half of Willow Creek drainage - some 10 or 11 square miles which had not been burned - while a very severe flood occurred in the lower half, most of which burned over in 1949.

Several degrees of erosion were observed on the burned-over forest land in Willow Creek. Sheet erosion occurred wherever the ground was left bare (fig. 12), shoestring gullies occurred on bare ground wherever slopes were long enough for water to concentrate, and big gullies were cut in the bottoms of the draws (fig. 13).

Fig. 7 - Main channel of Mann Gulch at Transect "A" about 1/4 mile above its mouth. (a) In October 1949 soon after fire; (b) July 14, 1950 shows marks of runoff from spring snow melt; and (c) August 31, 1950 after storm of August 11, 1950. Drainage area about 900 acres.

Fig. 8 - Two views of channel of the small side draw where Transect "B" is located showing conditions in October 1949 (a), and on August 31, 1950, following the storm of August 11, 1950 (b). Drainage area about 50 acres.

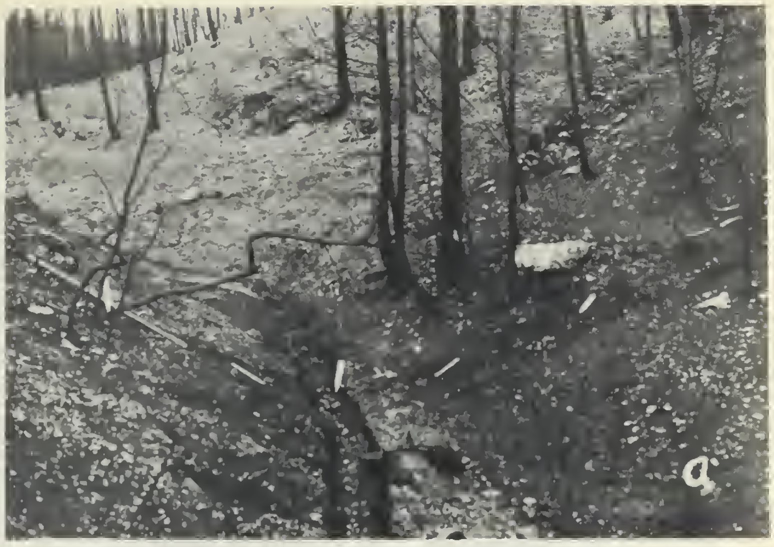


Fig. 9 - Three views of main channel of Mann Gulch at Transect "C". (a) In October 1949; (b) July 14, 1950; and (c) August 31, 1950. Drainage area about 500 acres.

Fig. 10 - Portion of a mud and rock flow which emerged from a burned-out side canyon on August 4, 1950, blocking the Willow Creek road. Drainage area about 150 acres.

Fig. 11 - Rocks and gravel in mouth of draw entering Willow Creek above Ives ranch. Flood waters came from burned-over mountains in background.

Fig. 12 - Nearly bare ground surface on a gentle slope near the base of Willow Mountain showing sheet erosion typical of the gentler terrain within the burned area.

Fig. 13 - A new gully formed in the bottom of the draw shown in fig. 11. This must have been the source of much of the debris dumped on the meadow below.

Fig. 14 - View of a side draw of about 50 acres which did not burn and from which apparently no surface runoff occurred. The view was taken looking directly up the channel in which the water would have flowed. It is only a few hundred feet from fig. 11.

There were patches of timber here and there in the vicinity of the Ives ranch that were not damaged by the fire (foreground, fig. 11). In these places it was impossible to recognize any signs of recent erosion, or even that a heavy rain had occurred. In figure 14 is shown a small unburned drainage a few chains west of the one in figures 11 and 13. It is noteworthy that obviously no water has entered this meadow from the forested area of about 50 acres. There is no question but that there would have been some very evident signs of erosion here, too, if soil surface conditions similar to those shown in figures 4 and 11 had existed in this small drainage.

Each year statistics are compiled to show timber values lost in the region due to forest fires. Less is said about loss of soil or watershed values, not because they are less important, but because they are less thoroughly understood and are harder to express in physical or monetary terms. In the case presented here, damage to soil and watershed values, loss of future productivity of the area, and damage done by the tons of rocks and debris deposited in the Missouri River probably far outweigh the timber values lost.

We cannot prevent rain from falling, but we can reduce or prevent damages from surface runoff by keeping the vegetal cover on our watersheds in good condition. If the "set-up punch" is blocked, the "knockout blow" is ineffective.

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